BOONTON ELECTRONICS CORPORATION

INSTRUCTION BOOK

MODEL 91K

HIGH IMPEDANCE RF MILLIVOLTMETER

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SECTION 1

SPECIFICATIONS

Voltage Measuring Range	1 mV to 30 V; to 300 V with accessory 100:1 Voltage Divider (see Table 1).
Full Scale Voltage Ranges	0.01, 0.03, 0.1, 0.3, 1, 3, 10, and 30 V.
Frequency Range	0.5 Mc/s to 600 Mc/s; uncalibrated response beyond 4000 Mc/s.
Accuracy	3% from 1 Mc/s to 100 Mc/s 5% from 500 Kc/s to 400 Mc/s 10% to 600 Mc/s On most sensitive (0.01 V, fs) range: 5% from 1 Mc/s to 400 Mc/s 10% from 500 Kc/s to 400 Mc/s 15% to 600 Mc/s
Noise	Indicator unrest is less than 2% fs on most sensitive (0.01 V, fs) range; sensibly zero on all other ranges.
dBm Range	80 dBm (-40 dBm to +40 dBm).
Waveform Response	True rms with input levels up to 300 mV; up to 30 V with accessory 100:1 Voltage Divider (see Table 1); gradually approaches peak-to-peak (calibrated in rms) at higher levels.
Crest Factor	420 to 1.4, depending on input level (see Table 11).
Power Sensitivity	0.02 microwatt, max.
VSWR	Less than 1.2

SPECIFICATIONS - continued

Linear DC Output..... Proportional rf input voltage; DVM Mode, full scale values continuously adjustable from 0 to 100 mV or 300 mV depending on range numerics; REC Mode, full scale value continuously adjustable from 0 to 300 mV for all ranges; Output resistance, 0 to 40 K, depending on setting of output level control.

Input Capacitance..... Approximately 2.5 pF (independent of input level).

Input Resistance..... Greater than 4 MΩ up to 25 Mc/s and greater than $\frac{100}{f_{Mc/s}}$ MΩ above 25 Mc/s (see Figure 1).

Standard Equipment..... The Model 91K is supplied with the following accessories which are included in the original cost:
Model 91-22A RF Probe with low noise cable and connector assembly; Model 91-3B Probe Tip; Model 91-8B 50 Ω BNC Adapter

Primary Power.....105/125 V, 60 c/s unless otherwise indicated on identification plate; 35 W.

Mechanical Specifications..... 7 1/4" W x 10 1/4" D x 11" H, excluding leather carrying handle; net weight, 12 lbs.; packed for shipment, 16 lbs.

IMPORTANT NOTE:

To exploit fully the capabilities of this instrument, the accessories listed below are required for the indicated ranges of operation.

TABLE 1 - REQUIRED ACCESSORIES

Measuring Range	Required Accessory	Remarks
100 Mc/s to 600 Mc/s	91-8B 50 Ω Adapter for shielded connection to 50 Ω line; other impedances available on request	Supplied as standard equipment with Model 91K
100 Mc/s to 600 Mc/s	91-14A Tee Connector and 91-15A 50 Ω Termination for connection into 50 Ω line	Available separately
Input levels up to 300 V; rms response with levels to 30 V	91-7C 100:1 Voltage Divider or 91-20A 10:1 Voltage Divider; operate over frequency range from 500 Kc/s to 600 Mc/s	Available separately

For details on the availability of these and other Boonton Electronics Accessories for RF Voltmeters, contact your local Boonton Electronics Sales Engineering Representative, or write directly to the factory at the address on the title page of this instruction book.

TABLE 11 - CREST FACTOR

Voltage Range	0.01	0.03	0.1	0.3	1*	3*	10*	30*
Crest Factor	420 to 42	42 to 14	14 to 4.2	4.2 to 1.4	420 to 42	42 to 14	14 to 4.2	4.2 to 1.4

* With accessory 100:1 Voltage Divider (see Table 1)

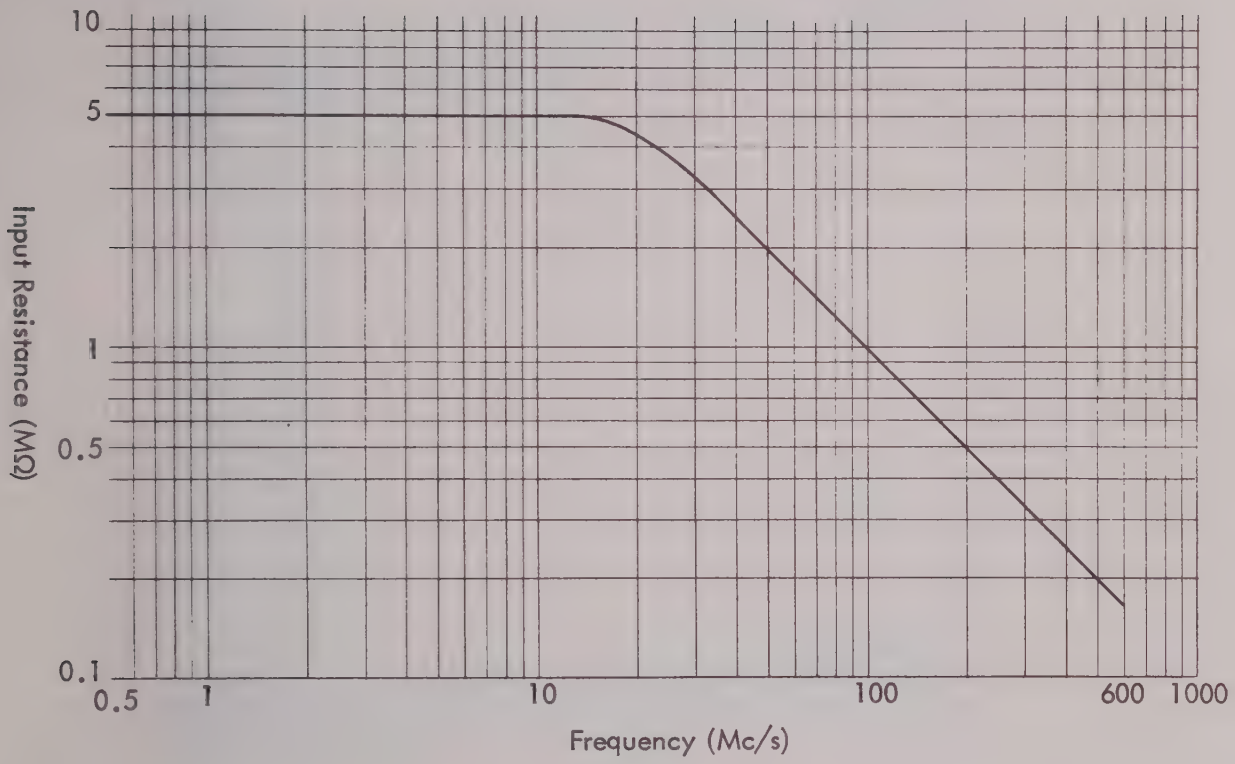
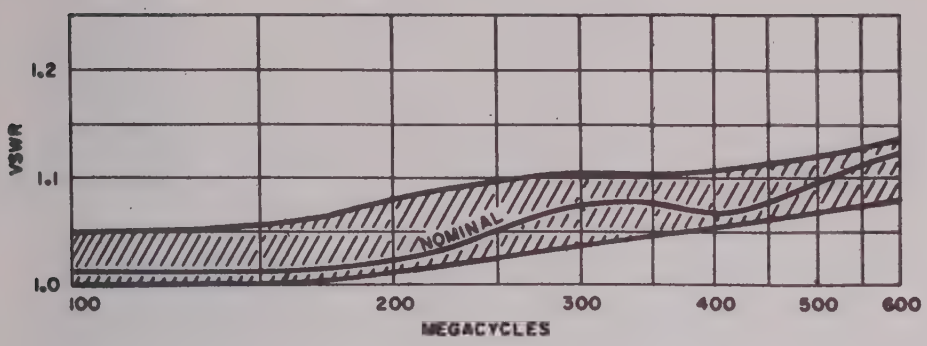
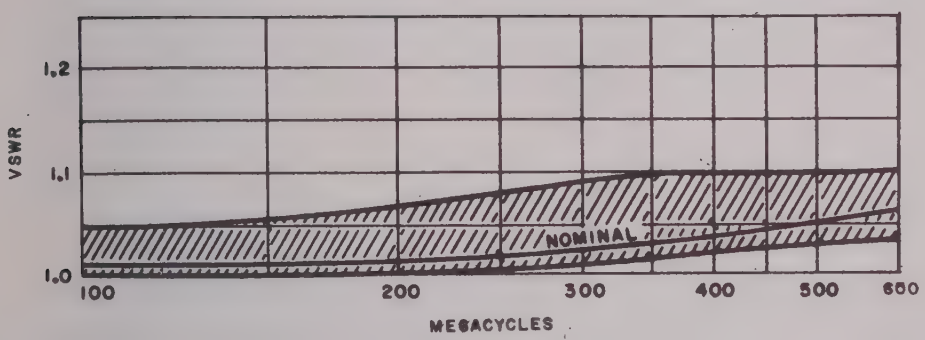


Figure 1. Minimum Input Resistance of 91-22 RF Probe



A

Using 91-8 50Ω Adapter



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Using 91-14 Type N Tee-Adapter and 91-15 50Ω Termination

Figure 2. Typical VSWR Characteristics of 91-22 RF Probe.

SECTION 11

GENERAL DESCRIPTION

The Model 91K is a highly sensitive voltmeter for measurements from the low radio frequencies to the 600 megacycle region, and over a voltage range from 1 mV to 30 V.

The instrument provides true rms response for input signals up to 300 millivolts, gradually approaching peak-to-peak response calibrated on the meter scale in rms above this level. The Model 91K is characterized by high input impedance (see Figure 1), excellent stability, and low noise.

As long as the measuring techniques outlined in this instruction book are followed, the accuracy and VSWR specifications of Section 1 apply without need for correction curves.

A linear dc output is provided at front panel terminals, whose level is proportional to the rf input voltage. This output is suitable for application to recorders, digital voltmeters, voltage comparators, or other external equipment.

APPLICATIONS

The Model 91K offers a convenient and accurate means for making a wide variety of high frequency voltage measurements. Typical examples include: determing the frequency response of both active and passive networks; measuring VSWR and return loss of tranmission lines and attendant systems; measuring attenuation and insertion loss of RF attenuators; measuring high frequency parameters of transistors and other semiconductors; and monitoring the output level of rf signal generators and the test signal level of high frequency impedance bridges.

Having true rms response, the Model 91K is valuable for measuring broadband noise. The instrument is also useful as a peak indicator and as an RF null detector for bridge measurements where a sensitivity of 1 mV will suffice.

Models 91K and 91KR

This instruction book applies to both the Model 91K and 91KR High Impedance RF Millivoltmeter. Electrically the two instruments are identical. The Model 91KR differs physically from the Model 91K in the following ways:

1. The Model 91KR measures 19" w x 5" h (panel dimensions) x 10" d; it mounts in a standard 19-inch rack.
2. The DC ADJ control, which adjusts the dc output level, is located on the front panel of the Model 91KR rather than at the rear, as in the Model 91K.
3. Input and dc-output connections are provided at BOTH the front panel and rear panel of the Model 91KR.
4. The calibration adjustments of the Model 91KR are located along the right and left sides of the main amplifier chassis. Adjustments 1 through 6 are accessible through ports along the right side of the instrument; adjustments 7 through 11 are accessible by removing the dust cover.

NOTE:

In calibrating the Model 91KR, care should be taken not to leave the dust cover open longer than required while adjusting controls 7 through 11, to avoid thermal changes which could affect the accuracy of calibration.

SECTION 111

OPERATING PROCEDURE

This section contains information essential to successful use of the Model 91K. It should be read carefully before operating the instrument.

3.1 INSTALLATION PROCEDURE

After the instrument has been unpacked and inspected visually for possible damage sustained in transit (if damage is found follow the shipping instructions in the warranty at the back of this instruction manual), it may be put into service by the following procedure:

a. Check the pointer zero position and if necessary adjust the mechanical zero control so that the pointer is aligned with the zero reference (the black line immediately to the left of the red 1 mV calibration).

b. With the power cord plugged into a suitable ac power source, turn the instrument on and allow a warm-up period of approximately one minute. IMPORTANT - The instrument should be plugged only into a power source having the voltage and frequency indicated on the instrument's identification plate.

c. Connect the probe cable to the PROBE jack on the front panel. IMPORTANT - Check to see that the serial number of the probe matches that of the RF Voltmeter. Each instrument is calibrated for its particular RF Probe. Use of a probe other than that for which the instrument was calibrated may result in errors in measurement.

3.2 OPERATING NOTES

While measuring with the Model 91K is a direct and straightforward process, there are certain precautions and procedures which MUST be observed to obtain satisfactory results.

3.2.1 Overload Limits

The RF Probe supplied with this instrument is overload protected to 100 volts, ac, and to 1000 volts, dc. EXCEEDING THESE LIMITS MAY RESULT IN PERMANENT DAMAGE TO THE PROBE.

The Model 91-8B 50 Ω Adapter should not be subjected to continuous overload of more than 10 volts (dc + rms ac) to avoid excessive heating of the terminating resistors.

In instances where voltages above these limits are likely to be encountered, the Model 91-7C 100:1 Voltage Divider or Model 91-20A 10:1 Voltage Divider is required. Maximum rating of the Voltage Divider is 1000 volts, dc + peak ac.

3.2.2 Connection for Measurements Below 100 Mc/s.

The RF Probe supplied with the Model 91K is equipped with a detachable tip and ground lead. For measurements of signals below approximately 100 Mc/s this tip provides a convenient means for both signal and ground connection.

3.2.3 Connection for Measurements Above 100 Mc/s.

For frequencies above 100 Mc/s, the probe tip should NOT be used. Connection should be made directly to the center contact of the probe with the ground connection kept as short as possible (see Figure 3). Under no circumstances should clip leads be used for either signal or ground connection.

Because of the difficulty in making a connection such as shown in Figure 3, the procedures outlined in Table 111 are strongly recommended to maintain specified accuracy.

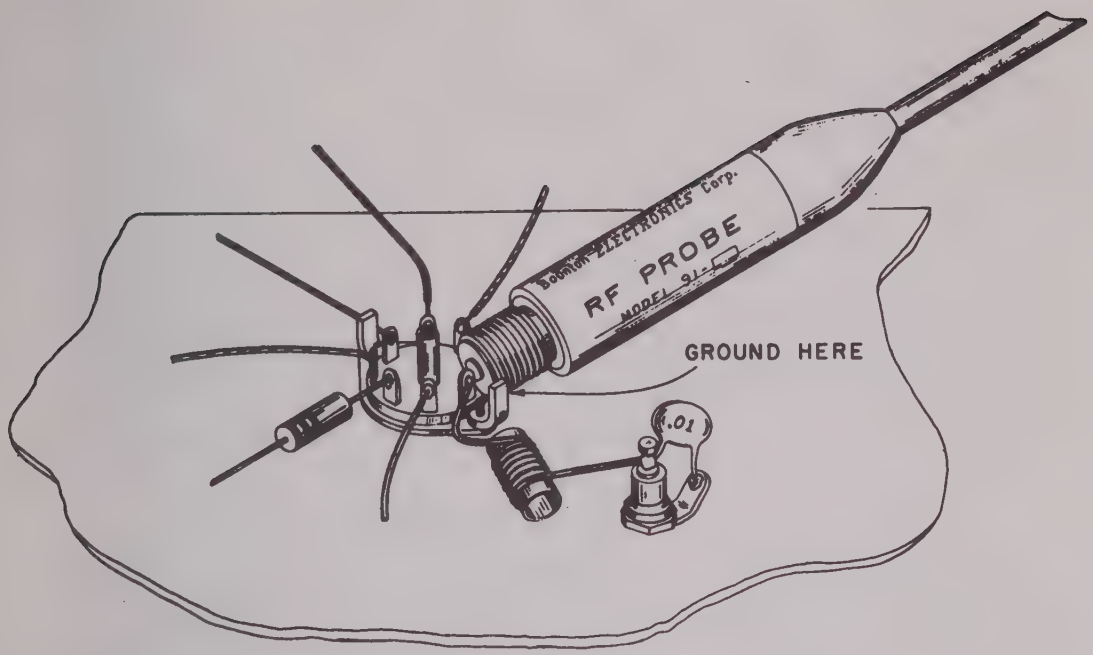

Figure 3. Method for making low inductance connections to test signal point directly using the RF Probe. Use for in-circuit measurements when lowest capacitance loading is required or when ground lead inductance of Probe Tip cannot be tolerated.

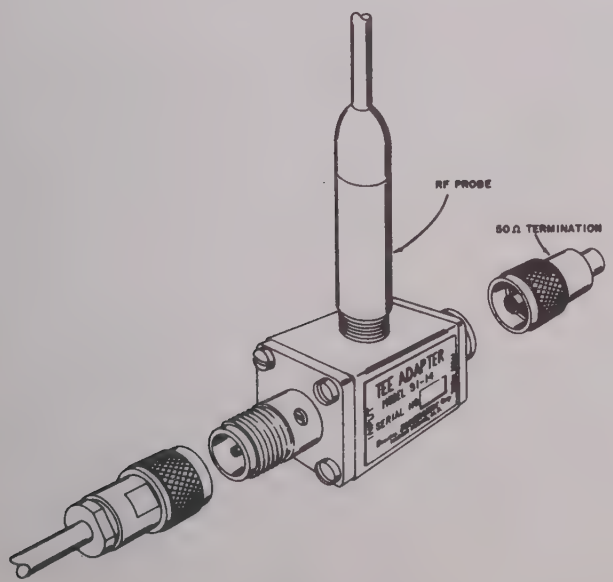

Figure 4. Assembly of 91-14 Type N Tee Adapter

TABLE 111

Frequency	Signal Connection
Up to 100 Mc/s	Probe Tip and grounding lead.
100 Mc/s to 250 Mc/s	Probe without tip (see Figure 3).
250 Mc/s to 600 Mc/s	Probe with 91-8B 50 Ω BNC Adapter (supplied with 91K)
Beyond 600 Mc/s	Probe with 91-14A Tee Adapter and 91-15A 50 Ω Termination (see Figure 4).

3.2.4 Low Level Measurement.

The Model 91K will provide reliable, reproducible measurements of signal levels as low as 1 mV using the red sub-calibrations on the voltage scale.

NOTE:

These sub-calibrations are for use on the 0.01 V range only. They should not be used for measurements on any other voltage range.

When using the most sensitive range (0.01 V), preliminary zero adjustment is required. On the 0.01 V range, particularly for measurements below mid-scale, proper zero adjustment is essential to achieve specified accuracy. For up-scale readings on this range, zero adjustment is less critical although still recommended.

3.2.5 Making the Zero Adjustment.

When the instrument is to be used on the 0.01 V range, the following zero adjustment procedure applies:

a. Set the RANGE FULL SCALE selector to the 0.01V position.

b. Check to see that no voltage is applied to the probe, and that the probe is adequately shielded from local fields (for test procedure, see Paragraph 3.2.9).

c. Adjust the ZERO control to bring the pointer in the direction of the zero reference (the black line immediately to the left of the red 1 mV calibration). Since there is some delay between adjustment of the control and the motion of the pointer, over-or-under-shooting the zero reference on the first attempt is not unlikely. After this initial coarse adjustment, wait for a moment or two for the pointer to come to rest. Then apply a series of small, corrective adjustments, waiting between each for the pointer to assume its new position until proper zeroing is achieved.

NOTE:

Because of the great sensitivity of the instrument on this range, indicator fluctuations of ±2% of full scale or less is to be expected. Proper zero adjustment is achieved when the pointer fluctuates equally above and below the zero reference line.

3.2.6 Normal Pointer Rest Position.

Depending on the range setting, the pointer may or may not normally rest at the zero reference with no signal applied. The rest positions indicated below are proper for the particular range; they do not indicate a need for either electrical or mechanical re-zeroing.

FS Range	Rest Position
0.01 V	Adjusted to zero reference (see above).
0.03 V	Approx. 1/16 inch up-scale.
0.1, 0.3, 1, 3, 10 V	At zero reference.
30 V	Approx. 1/16 inch down-scale.

3.2.7 Signal Overload on 0.01 V Range.

On the most sensitive (0.01 V) range, application of a large ac signal overloads the amplifier and a short time is required for the high impedance input circuit to discharge. This effect is of significance for signals above approximately 1 V. Typically, application of a 10 V signal will require a recovery time of about one minute before subsequent measurements should be made. It should be noted, however, that such overloads cause no damage to the equipment as long as they are within the limits outlined in Paragraph 3.2.1.

3.2.8 Temperature Effects.

The accuracy specifications for the Model 91K apply over the temperature range from 65° F to 90° F. Outside of these limits operation of the equipment is possible but appreciable inaccuracies can be expected. However, no permanent change in probe characteristics will result from any reasonable high or low temperature exposure.

It should be noted that inaccuracies of measurement resulting from temperature effects may occur shortly after soldering to the probe tip or measuring with the probe in the vicinity of heat sources such as resistors, heat sinks, vacuum tubes, etc.

When making low level measurements (below approximately 20 mV) it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and outside of the probe can generate a small thermal voltage that may add or subtract with the dc output generated by the detector diodes.

3.2.9 Hum, Noise, and Spurious Pick-Up.

When measuring low level signals precautions should always be taken to avoid the possibility of errors of measurement resulting from hum, noise, or stray rf pick-up. Although all low frequency hum and noise are attenuated at the input, it is still possible for unwanted high level signals to cause errors. The best test for local pick-up is to reduce the test signal level to zero and then note whether the pointer comes to

the rest position appropriate for the range setting (see Paragraph 3.2.6, above). In some cases it may be necessary to provide extra shielding around the probe connections to reduce stray pick-up. Typical sources of spurious radiation are: induction or dielectric heating units, diathermy machines, local radio transmitters, grid dip meters, and amplifiers with parasitic oscillations.

3.3 LINEAR DC OUTPUT

The dc output provided at front panel binding posts is a linear function (typically within 1%) of the rf input level, as long as the input signal is greater than 3 mV. For inputs less than 3 mV the output is NOT linear, and its use is not recommended. Polarity of the dc output is negative with respect to the instrument ground, the positive dc output terminal being at ground potential. Output impedance is less than 40 K, depending on output level setting.

3.3.1 DC Output Modes.

The linear dc output is available in two modes to meet the needs of various requirements. Mode selection is accomplished by jumper connections at the rear of the instrument.

a. REC (Recorder) Mode

In the REC Mode, the dc output is continuously adjustable from 0 to 300 mV, full scale, on all ranges.

b. DVM (Digital Voltmeter) Mode.

In the DVM Mode, full scale value of the dc output is continuously adjustable from zero to 100 mV for all "1" ranges, and to 300 mV for all "3" ranges, with the full scale value following the scale numerics when switching ranges.

3.3.2 Adjustment of DC Output Level.

Full scale value of the dc output can be adjusted within the specified limits (see Table 1) by applying an rf signal to the input which produces full scale deflection, and adjusting the DC OUTPUT LEVEL control (at rear panel) while monitoring the output with a high impedance dc voltmeter, such as the Boonton Electronics Model 95A, 97A, or 98A.

Adjustment of the dc output level has no influence on the instrument's calibration accuracy. A full short circuit across the dc output terminals does not effect the meter reading.

SECTION IV

THEORY OF OPERATION

An understanding of the operation of the Model 91K RF Voltmeter may be gained from the Block Diagram of Figure 5. The instrument comprises essentially a solid state detector probe, a highly sensitive, stable, chopper type dc amplifier, and a dc voltmeter.

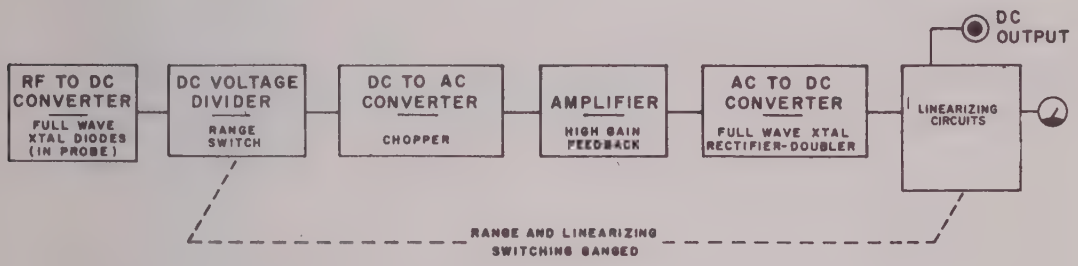

Figure 5. Block Diagram, Model 91K

4.1 RF PROBE

The RF Probe embodies a full wave diode detector which rectifies the signal under study to a dc voltage whose level is a function of the input level. While operating in the square-law region (below approximately 300 mV) the detector provides true rms response. As the input level increases beyond 300 mV, waveform response gradually approaches peak-to-peak, calibrated on the scale in rms.

In addition to increasing efficiency, use of full wave rectification in the detector probe permits measurement of signals having highly asymmetrical waveforms without errors stemming from turn-over effect.

The diodes used in the RF Probe have been carefully selected for specific characteristics. The user is urged NOT to attempt their replacement with any off-the-shelf types. In case of damage to probe components, contact your local Boonton Electronics Sales Engineering Representative or the factory for instructions.

4.2 AMPLIFIER

The dc output from the probe is passed through a voltage dividing network (range selector) where it is attenuated as required before being converted to ac at power-line frequency by the low noise chopper. The chopper output is applied to the narrow band, feed-back stabilized amplifier. Filter networks at the input, centered at line frequency, greatly attenuate extraneous noise and rf pick-up to the point where special precautions to avoid the effects of external fields are required only under the most unusual circumstances.

The ac output from the amplifier is then rectified by a voltage doubler and passed through a diode network to convert the signal to a linear voltage suitable for metering. The output of the linearizing network is also available at front panel terminals for external use.

SECTION V

MAINTENANCE

5.1 PERIODIC CALIBRATION

The Model 91K is designed to provide trouble-free operation over extended periods of time. However, as is the case with any precision instrument, the Model 91K should be checked periodically to verify proper calibration. To make such calibration checks, the following equipment is required:

a. A reliable signal source of 500 Kc/s to 1 Mc/s with less than 1% distortion at levels up to 30 V.

b. A precision electronic voltmeter of the averaging type such as the Ballantine Model 310A or 314, or the Hewlett-Packard Models 400D or 400H.

5.2 PRECAUTIONS WHEN CHECKING CALIBRATION

Before checking calibration, the accuracy of the ac monitoring meter should be verified using a low frequency (50 - 100 c/s) source of good waveform and a dynamometer type ac meter of at least 1% accuracy.

When checking the calibration on an instrument having the sensitivity and bandwidth of the Model 91K, it is essential to take precautions to avoid errors resulting from stray pick-up voltages. (See Paragraph 3.2.9). A well shielded signal source must be used in conjunction with coaxial connections to both the Model 91K and the standard reference meter. Even with a well shielded generator and associated connections, it is sometimes possible for the reference meter to pick up stray RF signals and feed them into the probe. It is advisable to test for this condition by disconnecting the standard meter and noting any change in level.

5.3 CALIBRATION CHECK

Using the equipment reference in Paragraph 5.1 and observing the procedure outlined in Paragraph 5.2, the calibration of the Model 91K should be checked on each range using a test voltage equal to the full scale value. If the check reveals that recalibration is required, the procedure outlined in Paragraph 5.4 should be followed.

5.4 CALIBRATION PROCEDURE

The Model 91K should be calibrated only when it is fully warmed up (after at least 30 minutes). DO NOT REMOVE THE INSTRUMENT FROM ITS CASE FOR CALIBRATION.

Access ports to all calibration controls are located along the lower right and left sides of the instrument. The control identification numbers referenced in the following procedure appear on the plates mounted just above the access ports.

Step 1. Set RANGE-FULL SCALE selector to 0.01 V range and zero the instrument. (See Paragraph 3.2.5).

Step 2. Set RANGE-FULL SCALE selector to 10 V range; set control No. 2 fully clockwise; apply 3 V input; adjust control No. 1 for 3 V reading.

Step 3. On 10 V range, apply 9 V input and adjust the control No. 2 for 9 V reading.

Step 4. On 10 V range, apply 3 V input again and readjust control No. 1 for 3 V reading.

Step 5. On 10 V range, apply 9 V input again and readjust control No. 2 for 9 V reading.

Step 6. Alternately repeat Steps 4 and 5 until range is calibrated (when adjustment of one control ceases to require readjustment of the other).

Step 7. Set RANGE-FULL SCALE selector to 30 V range. Apply 25 V input and adjust control No. 3 for 25 V reading.

Step 8. Set RANGE-FULL SCALE selector to 3 V range. Apply 2.5 V input and adjust control No. 4 for 2.5 V reading.

Step 9. Set RANGE-FULL SCALE selector to 1 V range. Apply 0.9 V input and adjust control No. 5 for 0.9 V reading.

Step 10. Set RANGE-FULL SCALE selector to 0.1 V range. Apply 0.03 V input and adjust control No. 6 for 0.03 V reading.

Step 11. Without altering range setting, apply 0.06 V input and adjust control No. 7 for 0.06 V reading.

Step 12. Without altering range setting, apply 0.09 V input and adjust control No. 8 for 0.09 V reading.

Step 13. In sequence, repeat Steps 10, 11, and 12 several times until range is calibrated.

Step 14. Set RANGE-FULL SCALE selector to 0.3 V range. Apply 0.3 V input and adjust control No. 9 for 0.3 V reading.

Step 15. Set RANGE-FULL SCALE selector to 0.03 V range. Apply 0.025 V input and adjust control No. 10 for 0.025 V reading.

Step 16. Adjust ZERO as in Paragraph 3.2.5.

Step 17. Set RANGE-FULL SCALE selector to 0.01 V range. Apply a 0.009 V input and adjust control No. 11 for 0.009 V reading.

Step 18. Alternately repeat Steps 16 and 17 until range is calibrated.

Calibration of the Model 91K is now complete, except for a brief check, as outlined in Paragraph 5.3 to assure that the calibration has been properly accomplished.

5.5 TROUBLE SHOOTING PROCEDURE

5.5.1 Case Removal.

The instrument may be removed from its case after first removing the two screws located at the back of the case (near the botton) and the four screws located on the sides of the case near the front.

The power supply may be removed from the case after removing the four screws located on the sides of the case near the rear.

5.5.2 Tube Replacement.

If the tube V1 should become weak or noisy, it should be replaced with BEC 525001 or a commercial low noise 12AX7. The Telefunken ECC83/12AX7 has been found to meet these requirements consistently. After replacing defective tubes, check calibration as outlined in Paragraph 5.3 and calibrate, if necessary, as described in Paragraph 5.4

5.5.3 Chopper Replacement.

If satisfactory operation is not obtained by replacing tubes, a replacement chopper should be tried.

NOTE:

The chopper used in the Model 91K is a special BEC part. For replacements or spares, contact your local Boonton Electronics Representative, or call the factory directly.

If the new chopper does not clear the difficulty, place the original chopper back in socket. The calibration accuracy must be re-checked and, if necessary, the instrument should be recalibrated.

5.5.4 Voltage and Resistance Tests.

After determining that the trouble cannot be cured by replacement of tubes or chopper (as described above) it is advisable to make a systematic check of the ac voltage, dc voltage, and resistance to ground from each pin of each tube socket. Table IV shows the nominal ac and dc voltages to ground from each pin; Table V shows the nominal resistances to be expected at each point. Large or erratic deviations from the listed values will serve as a valuable clue in tracking down a faulty component. Once the trouble has been found and corrected, the calibration must be re-checked and readjusted as outlined in Paragraph 5.3 and Paragraph 5.4.

TABLE IV

VOLTAGE MEASUREMENTS

Conditions:

117 V 60~ line input.
VTVM used for all measurements.
All measurements to chassis unless otherwise noted.
Input 0.1 V at any frequency between 500 Kc and 1 Mc.
Use Ballantine Model 314 VTVM, or equivalent, for all AC voltage measurements.
RANGE-FULL SCALE selector set to 0.1 V range.

Pin #		1	2	3	4	5	6	7	8	9	10	11
Tube	DC	140V	1.5mV	0.6V	0.75V	6.3V	85V	0	0.8V	0	-	-
V101 Ass'y	AC			0.1V	1.5mV		0.1V				-	-
	DC	0.5	1.5	12.6	6.3	11	24	1.5	-	-	-	-
V102 (6AU6)	AC	0.1	0.1	0.4	25mV	0.5	0.15	0.1				
	DC	300	125	45	0	0	1.5	0	170	100	-	-
V103 (7199)	AC	0.4	20	1V	0	6.3	5mV	70mV	20	20	-	-
	DC							350				
V201 (6X4)	AC	340		6.3	0		340					
	DC	150				150						
V202 (OA2)	AC											
	DC							150	300	0	0	12.6
11 Pin Socket	AC	6.3	0	115								
	DC											
Chopper Socket	AC			1.5mV	1.5mV							
				DC	12.6							
Pin 10 to Pin 11 of 11 Pin Socket				AC	0.4							
				DC	+6.3							
Pin 10 to Pin 5 of 11 Pin Socket				AC	0.4							

TABLE V

RESISTANCE MEASUREMENTS

Conditions:

Power turned off.

Tubes in socket, chassis interconnected (11 Pin), all measurements to chassis.

Pin #	1	2	3	4	5	6	7	8	9	10	11
Tube											
V101 Ass'y	65K	6.8M	835K	11K	4Ω	500K	100Ω	6.8K	0	-	-
V102 (6AU6)	835K	3.8K	8Ω	4Ω	500K	1M	3.8K	-	-	-	-
V103 (7199)	30K	250K	1M	0	0	1.2K	1M	20K	1M	-	-
V201 (6X4)	250	-	0	0	-	250	30K	-	-	-	-
V202 (OA2)	20K	0	-	0	20K	-	0	-	-	-	-
11 Pin Conn.	0	0	∞	∞	4Ω	-	20K	30K	0	8Ω	4Ω

5.5.5 Replacement of DC Output Level Potentiometer (R151).

If it should become necessary to replace the dc output level control (R151), it is possible that R150 will require replacement as well. R150 is selected to provide maximum accuracy of dc output in the DVM Mode when switching from a "1" range to a "3" range, or vice versa. If R151 is replaced, check to see that full scale dc output values alternate exactly between 100 and 300 mV when switching from "1" to "3" ranges. Otherwise, select a value for R150 which will accomplish this.

5.5.6 Replacement of RF Probes.

The serial number of the instrument matches that of this RF Probe with which it was calibrated at the factory. If it is necessary to change probes for any reason, the instrument's calibration MUST be rechecked. In the majority of cases, full recalibration (see procedure in Paragraph 5.4) will be required.

5.5.7 Replacement of XV101 Assembly.

The components making up the XV101 Assembly of this instrument have been incorporated in a module which may be removed as a unit in the following manner:

> Remove V101. Remove the screws securing the base shield of V101 and remove the base shield. The RFI Module, of which the socket is a part, may now be withdrawn from the chassis. The Module is force fit in its shield, from which it can be removed by pulling the shield down from the socket.

The RFI Filter Module is available for replacement as an assembled unit, and is designated by the BEC part number: 091,870.

TABLE OF REPLACEABLE PARTS

Reference	Description	BEC Part No.
C101	Capacitor, 0.1 µF 50 V 10%	234,046
C102	" 0.1 µF 50 V 10%	234,046
C103	" 0.1 µF 50 V 10%	234,046
C104	" 0.1 µF 50 V 10%	234,046
C105	" 0.022 µF 200 V 20%	234,042
C106	" .05 µF 200 V	230,117
C107	" 0.0033 µF 200 V 10%	234,043
C108	" Elect. 50 µF 6 V	283,145
C109	" 0.0033 µF 200 V 10%	234,043
C110	" Elect. 30 µF 350 V	283,161
C111	" Elect. 50 µF 6 V	283,145
C112	" 0.1 µF 200 V 20%	230,116
C113	" 0.022 µF 200 V 20%	230,101
C114	" 0.1 µF 200 V 20%	230,116
C115	" 0.1 µF 200 V 20%	230,116
C116	" 0.047 µF 200 V 5%	234,026
C117	" 50 µF 6 V	283,145
C118	" 0.002 µF 200 V 5%	234,024
C119	" 0.033 µF 200 V 5%	234,025
C120	" 0.033 µF 200 V 5%	234,025
C121	" 100 µF 6 V	283,171
C122	" 0.5 µF 200 V	230,135
C123	" 0.022 µF 200 V 20%	230,101
C124	" 0.1 µF 200 V 20%	230,116
C125	" 0.1 µF 200 V 20%	230,116
C126	" Elect. 50 µF 6 V	283,145
C127	" 0.1 µF 200 V 20%	230,116
C128	" 1 µF 200 V	230,104
C129	" Elect. 5 µF 50 V	283,143
C201	" 3X20 µF 450 V	283,113
C202	" 2X1000 µF 15 V	283,114
CR101	Diode, Silicon 1N251	530,043
CR102	" SG3113	530,040
CR103	" 1N600	530,008
CR104	" 1N600	530,008
CR105	" SG3113	530,040
CR106	" SG3113	530,040
CR201	Rectifier Sarkes Tarzian	532,001

	Reference	Description	BEC Part No.
DS101	Lamp	GE #51	545,103
DS102	Lamp	GE #51	545,103
F101	Fuse	MDL-0.5 Amp	545,504
G101	Chopper	BEC Special	540,113
L101	R.F. Coil	4.7 μH	400,113
L103	R.F. Coil	470 μH	400,116
L201	Choke	Stancor #C-1707 7 HY	440,001
M101	Meter	190 μA	554,161
R101	Resistor,	675 Ω 1/2 W 1%	306,695
R102	"	1.39 K 1/2 W 1%	306,694
R103	"	6.65 K 1/2 W 1%	306,338
R104	"	45.3 K 1/2 W 1%	306,437
R105	"	511 K 1/2 W 1%	306,564
R106	"	5.11 M 1/2 W 1%	306,788
R107	"	330 K 1/2 W 5%	301,147
R108	"	675 Ω 1/2 W 1%	306,695
R109	"	1.39 K 1/2 W 1%	306,694
R110	"	6.65 K 1/2 W 1%	306,338
R111	"	45.3 K 1/2 W 1%	306,437
R112	"	511 K 1/2 W 1%	306,564
R113	"	5.11 M 1/2 W 1%	306,788
R114	"	330 K 1/2 W 5%	301,147
R115	"	2.2 K 1/2 W 5%	301,095
R116	"	10 Ω 1/2 W 5%	301,039
R117	"	120 Ω 1/2 W 5%	301,065
R118	"	2.7 K 1/4 W 5%	300,092
R119	"	6.8MegΩ 1/4 W 5%	300,174
R120	" Var.	50 K	311,125
R121	"	10 Ω 1/2 W 5%	301,039
R122	"	1 MegΩ 1/2 W 5%	301,159
* R123	"	**845** Ω 1/2 W 1%	**306,231**
R124	"	10 K 1/2 W 1%	306,359
R125	"	825 K 1/2 W 1%	306,589
*R126	"	220 K 1/2 W 5%	301,143
R127	"	6.8 K 1/4 W 5%	300,102
R128	"	2.2MegΩ 1/4 W 5%	300,162
R129	"	100 Ω 1/2 W 5%	301,063
R130	"	470 K 1/4 W 5%	300,146

Reference	Description						BEC Part No.
R131	Resistor,		6.8	K	1/2 W	5%	301,107
R132	"		47	K	1/2 W	5%	301,127
R133	"		1	K	1/4 W	5%	300,082
R134	"		3.9	K	1/2 W	5%	315,002
R135	"	Var.	5	K	2 W	20%	311,101
R136	"		470	K	1/2 W	5%	301,151
R137	"		1	M	1/2 W	5%	301,159
R138	"	Var.	2	K	2 W	10%	311,126
R139	"	Var.	5	K	2 W	20%	311,101
R140	"		200	K	1/2 W	5%	301,142
R141	"		200	K	1/2 W	5%	301,142
R142	"		560	K	1/2 W	5%	301,153
R143	"		51	K	1/2 W	5%	301,128
R144	"		576	K	1/2 W	1%	306,570
R145	"		43	K	1/2 W	5%	301,126
R146	"		68	K	1/2 W	5%	301,131
R147	"		20	K	1/2 W	5%	301,118
R148	"		1	MegΩ	1/2 W	5%	301,159
R149	"		100	K	1/2 W	5%	301,135
*R150	"		8.2	K	1/2 W	5%	301,109
R151	"	Var.	50	K	2 W	10%	311,208
R152	"		51	K	1/2 W	5%	301,128
R153	"		51	K	1/2 W	5%	301,128
R154	"	Var.	50	K	2 W	20%	311,163
R155	"	Var.	25	K	2 W	20%	311,115
R156	"	Var.	25	K	2 W	20%	311,115
R157	"	Var.	25	K	2 W	20%	311,115
R158	"	Var.	25	K	2 W	20%	311,115
R159	"		1.2	K	1/2 W	5%	301,089
R160	"		220	K	1/2 W	5%	301,143
R161	"	Var.	250	K	2 W	20%	311,103
R162	"		330	Ω	1/2 W	5%	301,075
R163	"		1	MegΩ	1/2 W	5%	301,159
R164	"		1	MegΩ	1/2 W	5%	301,159
R165	"		680	Ω	1/2 W	5%	301,083
R166	"		3.3	K	1/2 W	5%	301,099
R167	"		20	K	2 W	5%	304,118
R168	"		4.7	K	1/2 W	5%	301,103
R169	"	Var.	10	K	2 W	20%	311,102
R170	"		30	K	1 W	5%	302,136
R171	"		4.7	K	1/2 W	5%	301,103
R172	"		100	K	1/2 W	5%	301,135

	Reference	Description	BEC Part No.
R173	Resistor, Var.	2 MegΩ 2 W 20%	311,195
R174	"	30.1 K 1/2 W 1%	306,416
R175	"	68 K 1/2 W 5%	301,131
R176	"	9.53 K 1/2 W 1%	306,357
R177	"	33.0 K 1/2 W 5%	301,123
R201	"	1 MegΩ 1 W ±20%	302,128
R202	"	5.6 K 2 W 5%	304,105
R203	"	10 K 10 W 5%	312,103
S101	Switch	Oak Type F	466,169
S102	Switch	SPST Carling 110-63	465,105
T201	Transformer	Power, Special	446,016
V101	Electron Tube	12AX7, Special	525,001
V102	Electron Tube	6AU6	526,6AU6
V103	Electron Tube	7199	526,7199
V201	Electron Tube	6X4	526,6X4
V202	Electron Tube	OA2	526,OA2
VR101	Diode, Zener	5.4 V 1/2 W 5%	530,020

*The following items are factory selected values.

NOTES
FOR 234V OPERATION, F101 SHOULD BE 0.25 AMP

FOR 234V OPERATION CONNECT BLK-RED & BLK-WHT TOGETHER.

RESISTANCE VALUES IN OHMS AND 1/2 WATT UNLESS OTHERWISE SPECIFIED.

CAPACITANCE IN μF UNLESS OTHERWISE SPECIFIED.
K=10^3 M=10^6.

● FACTORY SELECTED VALUE.

⊖ CALIBRATION CONTROL.

□ EXTERNAL MARKINGS.

LAST NUMBERS USED.
R177 C129
R203 C202

NOTES
COMPONENTS IN THE "PROBE" HAVE NOT BEEN SHOWN. IN GENERAL, THEIR REPLACEMENT MUST BE FOLLOWED BY ADJUSTMENTS THAT REQUIRE SPECIALIZED EQUIPMENT AND TECHNIQUES.

PROBE

POWER SUPPLY

SEE NOTES FOR 234V OPERATION

AMPLIFIER

SCHEMATIC

91K

MP MASTER
MA25160